

# GCE Examiners' Report

Chemistry

GCE

Summer 2025

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## Introduction

Our Principal Examiners' report provides valuable feedback on the recent assessment series. It has been written by our Principal Examiners and Principal Moderators after the completion of marking and moderation, and details how candidates have performed in each unit.

This report opens with a summary of candidates' performance, including the assessment objectives/skills/topics/themes being tested, and highlights the characteristics of successful performance and where performance could be improved. It then looks in detail at each unit, pinpointing aspects that proved challenging to some candidates and suggesting some reasons as to why that might be.<sup>1</sup>

The information found in this report provides valuable insight for practitioners to support their teaching and learning activity. We would also encourage practitioners to share this document – in its entirety or in part – with their learners to help with exam preparation, to understand how to avoid pitfalls and to add to their revision toolbox.

## Further support

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<sup>1</sup> Please note that where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

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## Executive Summary

The recent increase in entries continued this year with higher numbers for both AS units and around 2320 candidates cashing-in the A level. Mean marks on the A2 papers were higher than those on the AS papers. Performance was generally quite pleasing with some exceptional work seen from the best candidates.

Most candidates sitting AS papers showed basic knowledge in some areas but there were often gaps in other areas. Many showed good mathematical skills in application of the ideal gas equation and equilibrium constants but rearranging equations and converting units caused problems for some. In general, numerical problems that required a degree of planning were less well done.

Questions on practical methods often suggested a lack of first-hand experience of common techniques such as back titration and thermochemistry.

Marks were often lost for incomplete answers and lack of detail and precision, e.g. omitting key words and phrases from standard definitions and using bromine/bromide incorrectly. These points apply equally on the A2 papers where many confused ammonium and ammonia when describing salt hydrolysis.

Most candidates sitting A2 papers showed a breadth of specification knowledge with fewer significant gaps than those at AS. Application of knowledge in familiar contexts was usually good but errors seen in more unfamiliar questions exposed a lack of depth of understanding, e.g. when evaluating a practical method.

Good practical titration skills were demonstrated by most in the Experimental Task where the majority performed very well. Familiar calculations were again well done and whilst there was better application in unfamiliar contexts than seen at AS there were lots of examples of errors in the conversion of units.

Many candidates failed to give complete answers in questions that require comparison. For example, when they are asked to explain the different boiling temperatures of two compounds their answers must refer to both compounds to gain full credit.

Almost all candidates showed a degree of positive achievement and it was pleasing to see A grade boundaries at 60-70% of the available marks on all papers. Candidates and centres should reflect positively on this performance before targeting the areas highlighted for improvement in the body of this report.

# CHEMISTRY

## GCE

Summer 2025

### UNIT 1 – THE LANGUAGE OF CHEMISTRY, STRUCTURE OF MATTER AND SIMPLE REACTIONS

#### Overview of the Unit

The number of entries was up about 200 from last year to around 4150. The mean mark of 35.4 was about 2 marks lower than last year's mean. The highest mark scored was 77 out of 80. In Section B the most successfully answered question, as a whole, was Q9 with Q11 being the least successfully answered. The easiest items proved to be Q10(a)(i), Q9(b)(i)II and Q6(b), while the most difficult were Q12(c)(ii), Q11(c)(i) and Q11(c)(iii) in that order.

It was pleasing to note that good knowledge of writing formulae, flame tests and covalent bond formation was shown by many candidates. Most candidates also showed a fair knowledge of radioactivity and bond angles and shapes in molecules. However, as noted in previous reports, the examiners were disappointed with the standard of many of the answers given, including the QER question (Q13a). Too many marks are still lost in basic recall e.g. Q6(a) (solubility of sulfates), Q9(a)(i) (labelling mass spectrometer), Q13(b)(i) (definition of strong acid).

A significant number of candidates performed well in some familiar calculations e.g. Q10(a)(ii) (water of crystallisation), Q12(d) ( $pV = nRT$ ), Q12(e)(ii) (equilibrium constant). However, calculations that were slightly different were poorly answered e.g. Q9(c) (gravimetric analysis), Q12(c)(i) (molar ratio). Generally, candidates' understanding of numerical concepts is still lacking in depth and many still have difficulty in converting from one unit of measurement to another, rearranging the subject of a formula and using stoichiometry.

#### Comments on individual questions/sections

##### Section A

This section was fairly well answered with the mean mark being just over 5 out of 10.

Questions 1, 4, 6 and 7 were well answered.

The main errors in Q2 were referring to 'atoms' or 'molecules' instead of 'ions' and simply stating the coordination numbers of NaCl and CsCl. In Q8 the main error was not taking into account that there are two moles of N in one mole of N<sub>2</sub>O.

In Q3 just over a third gave the correct answer. Most candidates did not realise that frequency and energy are inversely proportional to wavelength.

Only about 20% gave a correct answer to Q5. Some candidates gave 2 as the total number because this is the number of full orbitals, but most gave 3 because they did not realise that there are three *p*-orbitals in a *p*-subshell.

## Section B

For this section the feedback will be grouped into the following skills and themes:

- Important concepts (bonding, equilibrium and acid-base reactions)
- Mathematical skills
- Practical aspects.

### Bonding

Q11(a) tested the candidates' knowledge of intermolecular bonding. Part (i) was about hydrogen bonding. Only around a quarter scored both marks.

The main errors were:

- not knowing that  $\text{NH}_3$  can form hydrogen bonds
- just stating that the intermolecular bonds in  $\text{PH}_3$  are weaker without mentioning the type of forces which are present
- not mentioning  $\text{PH}_3$  in the answer although a comparison was required.

Part (ii) was about van der Waals forces. Again, only about a quarter gained both marks.

The main errors were:

- stating that As is a larger atom than P without mentioning electrons
- simply stating that intermolecular bonding in  $\text{PH}_3$  is weaker than in  $\text{AsH}_3$ .

Q11(b) was about VSEPR theory. The vast majority scored at least one mark, usually for the number of bonding and lone pairs of electrons. A significant number also knew the shape of the molecule and a fair number also knew that the bond angle is between  $105^\circ$  and  $109^\circ$ . However, only a minority could use the VSEPR theory accurately. Some stated that 'the atoms position themselves as far apart as possible' without mentioning electron pairs but most simply stated that 'lone pairs repel more than bonding pairs' without mentioning minimum repulsion.

### Equilibrium and acid-base reactions

In Q12(e) candidates had to write an expression for  $K_c$  and calculate its value. In the first part although over three-quarters scored at least one mark, fewer than a half scored both marks.

The main errors were:

- putting a + sign between the concentrations of products and reactants
- not using square brackets for concentrations
- giving an incorrect unit for  $K_c$ .

In the second part just over half the candidates correctly calculated the value of  $K_c$ . A significant number lost the marks because they could not rearrange the expression to make  $[\text{CH}_4]$  the subject of the formula.

Q13(b) was about the properties of acids. In the first part candidates simply had to state what was meant by a strong acid. Just over half could do so. Some simply stated that it had a very low pH and many described a concentrated acid instead.

The second part was poorly answered. Less than half knew that weak acids have a different pH to strong acids and only a minority realised that the volume of ethanoic acid needed to neutralise a sodium hydroxide solution is the same as the volume of hydrochloric acid needed if both acids have the same concentration.

## Mathematical skills

Q9(c) was a gravimetric analysis calculation. Although there was an improvement from the last time a similar question was asked only around 20% gained all four marks while around 30% failed to score at all. Some marks were lost for failing to use the 2:1 ratio and for not giving the final answer to four significant figures. Many candidates did not understand the point of the question and used the  $A_r$  value of radium from the Periodic Table to find the number of moles of  $\text{RaCl}_2$  used. They were awarded only one mark.

In Q10(a)(ii), many succeeded in finding the number of moles of water of crystallisation. However, a large minority truncated the number of moles of water to 0.03. This gave a value of 5, so they lost a mark.

The percentage error calculation in Q10(a)(iii) was poorly answered. The most common answer was 0.31. Most did not realise that because there were two mass readings they had to multiply 0.05 by 2.

In Q12(c)(i) a molar ratio calculation proved to be very tricky. Only a minority gained all three marks.

The main errors were:

- calculating the number of moles of Li instead of  $\text{LiAlH}_4$
- truncating the number of moles of Al from 0.033 to 0.03
- not using  $n = \frac{V}{V_m}$  to calculate the number of moles of  $\text{H}_2$ .

Q12(d) using  $pV = nRT$  tested the candidates' ability to change the subject of a formula, to convert from one unit to another and to use stoichiometry. This was generally well answered with around a quarter scoring all four marks while around 20% failed to score any marks.

The main errors were:

- truncating to one significant figure during the calculation
- not using the stoichiometry, so failing to divide the numbers of moles of Li by 2
- incorrectly converting from  $\text{m}^3$  to  $\text{cm}^3$ .

In Q13(c) most candidates calculated the volume of acid at the new concentration, but only a minority subtracted the original volume to give the volume of water added.

In Q13(d) candidates had to calculate the minimum hydrogen ion concentration from a range of pH values. Almost everyone knew that  $[\text{H}^+] = 10^{-\text{pH}}$  but only around 40% based their calculation on the correct pH.

## Practical skills

Practical skills were mainly tested in Q10(b), Q10(c), Q11(c) and Q13(a). Q10(b) and Q10(c) were about the water of crystallisation of  $\text{SrCl}_2$ . Part (b)(i) was answered better than (b)(ii). In (b)(i) most candidates knew that less water would be lost if a yellow flame was used, however fewer than half correctly stated that the value of  $x$  would decrease. In (b)(ii), a number of candidates lost a mark for being too vague e.g. 'mass would be less' and 'less crystals left' were typical answers.

In Q10(c) candidates had to suggest two improvements to the experiment, giving reasons. Although over half gained at least two marks around a third did not score at all.

The most common incorrect answers suggested:

- that the experiment should be repeated
- using a balance with a greater numbers of decimal places
- heating for longer.

In Q11(c) candidates needed to know the observations in the test for halides and in the reaction between a halogen and a halide. This was very poorly answered. In part (i) the vast majority thought that the statement was correct and simply gave the colours of the silver halide precipitates, scoring no marks. Only a minority realised that the yellow precipitate would mask any white or cream precipitate. In part (ii) although the majority said that the statement was incorrect, only a small minority could give an adequate reason. Most candidates were not clear on the difference between halogens and halides. Consequently, they thought that 'iodine' could also be present because it could not displace 'bromide ions'. A few candidates stated that 'bromine water is a test for alkenes not halide ions'.

Q13(a), the QER question, was about a back titration. It was poorly answered with the mean mark being under 2 out of 6. Only a small minority of candidates obtained middle or higher band marks with over half not scoring at all. Despite being one of the specified practical tasks, most candidates did not have any idea how to perform a back titration although they were given an outline of the method. Maybe because 'standardised solution of NaOH' was written in the question many candidates wrote at length on how to make a standard solution of calcium carbonate – despite it being insoluble! Many also filled a burette with hydrochloric acid despite being told that they only had 25 cm<sup>3</sup> of it and that it was in a conical flask. However, they could still gain credit if they suggested a sensible use of the results. Some described simply titrating sodium hydroxide against hydrochloric acid without using the calcium carbonate at all, but they could still obtain marks if the titration details were correct.

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### UNIT 2 – ENERGY, RATE AND CHEMISTRY OF CARBON COMPOUNDS

#### Overview of the Unit

Based on available evidence from the performance data and examiner feedback, the paper was generally accessible, with most candidates attempting all questions.

However, the data also highlight some clear areas of underperformance, especially where questions required more than basic recall. A significant proportion of candidates struggled with retrieval tasks that required more than a surface-level understanding. This was evident in Q3(a) where fewer than half of all candidates could correctly sketch the Boltzmann distribution for a lower temperature and in Q5 where most failed to recognise the need to take account of geometric isomerism in the IUPAC name. Similarly, Q7(b)(ii) and Q9(b)(iii) exposed gaps in understanding with several candidates unable to apply knowledge to unfamiliar contexts or to demonstrate deeper understanding.

Even where candidates had learned definitions or core concepts, their responses often lacked the detail or accuracy needed to gain full marks. For instance, in Q8(b)(i) many candidates were unable to recall the standard definition of enthalpy change of formation. In Q4 and Q10(a)(iii) very few candidates were able to accurately draw and label mechanisms, highlighting a lack of precision in the use of curly arrows.

Overall, the paper revealed that although many candidates had clearly revised and could recall basic knowledge, understanding often lacked the depth needed to apply that knowledge in unfamiliar contexts. Questions involving practical methods were particularly problematic.

#### Comments on individual questions/sections

##### Section A

- Q.1** Over 80% of candidates who attempted this question gained the available mark, showing an improved understanding of drawing skeletal structures.
- Q.2** Over 80% of candidates who attempted this question gained the available mark.
- Q.3** (a) Asking for a lower temperature rather than a higher one for this Boltzmann distribution revealed a lack of understanding of what this curve represents, as less than half of candidates drew the curve correctly. The majority of candidates who answered incorrectly drew the curve for a higher temperature.  
(b) Over 80% of candidates who attempted this question gained the available mark. No credit was awarded for an 'alternative pathway' without reference to lower activation energy).

- Q.4** Many candidates gained the mark for correctly labelling the relevant dipole on the diagram, showing an improved awareness of the importance of labelling dipoles correctly. Few were able to gain the second mark, showing that the accurate use of curly arrows in mechanism diagrams is still not well learned or understood. Common errors included missing the  $\delta$  symbol when labelling the dipoles, failing to start the first curly arrow from the lone pair (or negative charge) of the hydroxide ion and starting the second curly arrow directly from the carbon atom rather than the covalent bond between the carbon and bromine atoms.
- Q.5** Many candidates gave the basic name of the molecule without realising that two geometric isomers are possible. Fewer than 10% of candidates attempted to include *E*- or *Z*- in the name. On the other hand, it was pleasing to see that most candidates who did so used the correct one. The most common error, other than omitting the prefix, was giving the main carbon chain as pent-3-ene.
- Q.6** (a) Over 80% of candidates who attempted this question gained the available mark.  
(b) Approximately half of all candidates answered this question correctly.

## Section B

### Question 7

- (a) (i) Approximately 70% of candidates gained this mark. The most common incorrect answers given in this question included photochlorination and halogenation. These are not mechanisms.  
(ii) Many candidates gained the first mark for the homolytic bond fission of chlorine molecules. In general, if they gained the first mark for the propagation step they were able to gain the second mark as well. Incorrect answers were varied and had no significant pattern.
- (b) (i) Over half of all candidates were able to gain this mark. Most answers not credited included inaccurate terminology and notation such as reference to 'methane radicals' and writing  $\text{CH}_3$  with no dot.  
(ii) Approximately one fifth of candidates gained both marks for this question and a good number gained one mark. This was usually for stating that the radical substitution reaction continued. The most common error by far was stating that diatomic chlorine reacts directly with methane or a methyl radical. This shows a significant lack of understanding of how this type of reaction can undergo multiple substitutions.
- (c) (i) This question was designed to test candidates' ability to evaluate an unseen situation so it is no surprise that just one quarter of candidates gained the mark. Common incorrect answers included less surface area for reaction and longer UV exposure time.  
(ii) The majority of candidates gained one mark out of two for this question for the correct flow rate. Very few candidates successfully explained this in terms of a balance between there being enough time to form the desired product but not enough for much of it to react further.

## Question 8

- (a) Over 70% of candidates who attempted this question gained the available mark. Common errors included drawing an exothermic profile and labelling the activation energy instead of the enthalpy change.
- (b) (i) Many candidates gained the first mark for the formation of one mole of a substance. However, relatively few gained the second mark. Common errors included reference to 1 mol of reactants and making no mention of standard states. This really should be two easy marks for candidates who have prepared well for the exam.
- (ii) Over half of the candidates who attempted this question gained at least two marks, showing a good understanding of the mathematical processes involved.
- (c) (i) The majority of candidates were able to plot the points correctly, although a small but significant number did not plot the points at 90s and 150s correctly. Very few gained the mark for drawing the line back to the time of mixing. The most common error was calculating the temperature change based on the initial temperature and the lowest recorded value, thus missing the point of drawing the graph.
- (ii) This question was done relatively well, with approximately one third of candidates getting all three marks. Another third only obtained two marks, having either not rounded to three significant figures or used the incorrect relative formula mass. Candidates who got one mark almost always got it for calculating the number of moles of the hydrated barium hydroxide.
- (iii) This question was answered relatively poorly, with less than one fifth of candidates obtaining both marks. A significant number gained the first mark for the correct formula, although a similar number tried to use the formula without dividing by the number of moles of barium hydroxide. Other common errors included giving a negative value for an endothermic process, adding 273 to the temperature difference before calculation and forgetting to convert the answer into  $\text{kJ mol}^{-1}$ .
- (d) (i) This question was answered extremely poorly, with less than 5% of candidates gaining the mark. The main error was candidates suggesting that heat was lost to the surroundings as has been commonly seen in previous papers.
- (ii) Over 70% of candidates who attempted this question gained the available mark. The most common incorrect answer suggested using a more precise or a digital thermometer.

## Question 9

- (a) This question was generally done well with most candidates scoring between five and nine marks. This type of organic analysis question is now familiar so this is not surprising. There were however numerous examples of candidates listing all the appropriate inferences but not pulling everything together to give the correct structure. Many identified the correct number of hydrogen/carbon environments from the NMR spectra but gave structures that did not fit those inferences.
- (b) (i) This question was done very well with approximately three quarters of candidates gaining the mark.  
(ii) Just under half of candidates gained the mark. It is clear that a significant number of candidates have little to no experience with working with this kind of oxidation equation.  
(iii) This question was done poorly with less than 10% of candidates gaining both marks and only about a quarter gaining one mark. The most common errors included not balancing the equation and writing the reduction equation.  
(iv) In part I, approximately half of all candidates gained at least one mark. Of those, similar numbers gave the correct ester structure as included water as a co-product. In part II, a little less than half of candidates named the ester correctly. In part III, a little less than half of candidates knew that sulfuric acid is a catalyst for this reaction.

## Question 10

- (a) (i) This question was answered adequately with a mean mark just under one. Those candidates who scored one mark usually got it for saying the reaction needed to be heated. The common errors included reference to aqueous conditions and excessively high temperatures (150-300°C).  
(ii) Approximately one third of candidates gained this mark, showing that most candidates do not know the difference between the molecule eliminated during a reaction and the product formed.  
(iii) This question was answered very well by a small number of candidates who had clearly learned their work well. Another small number of candidates gained one or two marks for correctly drawing the reactants or intermediates. Approximately half of all candidates gained no marks for this question, either leaving it blank or guessing the structures and arrows required. Some started with the incorrect reactants and the usual errors were seen in representing dipoles, full charges and the movement of electron pairs.
- (b) (i) Approximately one quarter of candidates gained both marks for this question, with another quarter gaining one mark out of two. The most common errors were often careless mistakes and included putting the isomers into the incorrect boxes, drawing but-1-ene and but-2-ene and drawing a carbon atom with too many or too few hydrogen atoms.  
(ii) This question was answered very well by approximately one quarter of candidates. Many understood that the products **A**, **B** and **C** were formed from secondary, tertiary and primary carbocations respectively, but there seem to be two major misconceptions about how this affects yield. Firstly, several candidates named **C** as the major product because the intermediate is less stable which makes the reaction go quicker. The second misconception is simply that the secondary carbocation is the most stable of the three, most likely due to candidates learning the example of propene without understanding the reasons why. A few candidates tried to base their explanations around Markovnikov's rule which, while being a good predictor of the major product, is not an explanation of the process.

## Question 11

- (a)
- (i) Very few candidates gained both marks for this question and just over one third gained one mark, usually for highlighting the formation of a precipitate. The most common errors were reference to colour change instead of precipitate formation and halogens instead of halides.
  - (ii) Very few candidates gained more than one mark for this question, usually for naming **A** as the reaction for 1-iodobutane. Few candidates were able to effectively communicate that reaction **A** finished first. Poor expression and lack of precision resulted in many lost explanation marks.
  - (iii) Very few candidates were able to gain both marks for this question. Of those who gained one mark, this was usually for the correct unit. This suggests that candidates do not know how to calculate a mean rate of reaction from a graph.
- (b) This QER question was very poorly answered. The purpose of questions like this is to test a candidate's understanding of the general principles of conducting an experiment, such as adapting specified practical methods, making the experiment fair by only changing one variable and keeping the others the same, using appropriate equipment and carrying out the steps in the correct order. The idea of dilution of the persulfate was often well understood but some showed a real lack of knowledge by only adding two of the three named reagents, not adding starch solution or indeed describing a totally different experiment (e.g. using silver nitrate to obscure a cross drawn on paper).

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### UNIT 3 – PHYSICAL AND INORGANIC CHEMISTRY

#### Overview of the Unit

Unit 3 examines candidates understanding of physical and inorganic chemistry. The mean mark was slightly above that of summer 2024. Most attempted all parts of the paper and only a handful of questions were attempted by fewer than 95% of candidates. The pattern of question attempts suggests that the length of the paper was appropriate. Most questions were accessible and discriminated well with the facility factor for almost all questions lying in the 45-75% range. All questions with lower marks are discussed in the comment section below.

The unit gives candidates the opportunity to show the full range of assessment objectives. It requires candidates to recall and apply knowledge and skills, to analyse evidence and come to judgments in both inorganic and physical chemistry contexts. Almost all candidates were able to recall and apply basic concepts and observations across a range of inorganic topics and perform simple calculations in physical chemistry. Questions combining both conceptual understanding and mathematical processing were more challenging and candidates scored lower marks on these. In general, practical based questions saw lower marks than those based on theoretical work.

#### Comments on individual questions/sections

##### Section A

Questions in Section A are short and specific and focus on AO1 and AO2 skills. The facility factor of most parts is over 70% showing that they were well answered by most.

Question 2 was the most poorly answered in Section A. Many candidates did not make a comparison and referred to silicon only with no reference to carbon. Those that did reference both often gave unclear or incorrect statements such as 'carbon has no inert pair effect', 'water can bond to the *p*-orbitals in silicon' and 'carbon has no *d*-orbitals'.

##### Section B

Many of the questions in Section B had lower facility factors than Section A but most are still above 50%. The discussion below covers all parts with facility factors below 50%.

Question 7(b) saw a wide range of incorrect answers and only one third of candidates gained the marks. Very many answers suggested that the salt would be basic or neutral. Most candidates who understood the acidic nature of the salt could explain this in terms of the release of protons by the ammonium ion though some lost a mark by referring to the release of protons by ammonia.

Question 7(d) was a challenging multistep calculation that required candidates to identify the gases present in the mixtures at different temperatures and then use these to find the number of moles of each present. Weaker candidates subtracted the volumes of the gas at 100K and 200K and then attempted to convert this volume into a number of moles rather than converting both volumes into moles before subtracting.

Question 8(a)(i) was very poorly answered with many candidates writing an equation for the formation of sodium chlorate(I) despite the question stating sodium chlorate(V). If candidates gave a correct balanced equation for the formation of sodium chlorate(I) they were allowed access to both marks in part (ii) as long as the oxidation states quoted matched their equation.

Question 8(b)(ii) was the most poorly answered question on the paper with many candidates using the fact that the reaction was first order with respect to a reactant to state that half-lives would be constant despite the reaction being second order overall. Some answers suggested that candidates were not aware that a first order reaction would have a constant half-life.

Question 8(b)(iii) required candidates to use a graph to calculate rates and rate constants. Most candidates gained some marks but few gained full marks. Common errors were including  $s^{-1}$  rather than  $min^{-1}$  in the units without adjusting the value to reflect this, including only one concentration in the rate equation rather than both and calculating the rate at a different point on the graph rather than the initial rate. A few candidates did not draw tangents and were penalised for this. In part III it was common to see candidates confusing 'bromide' and 'bromate' and hence giving an incorrect answer.

Question 9(b)(i) challenged some candidates. Many discussed the increased hydrogen ion concentration due to the strong acid HI but only a minority were able to link this to the position of the ethanoic acid dissociation equilibrium.

Question 9(b)(iii) was the QER question. Candidates always find buffer calculations and explanations challenging. In this question, a buffer could be produced by addition of sodium ethanoate or addition of sodium hydroxide. Some could explain how the buffer works but few could calculate the mass or concentration of a solution of either of the reactants that could be added to the ethanoic acid to ensure the desired pH.

Question 9(c)(i) has a facility factor of 45%. The unfamiliar context and layout seem to have thrown many candidates on what is a relatively straightforward question. Fewer than half were able to deduce that the reaction is exothermic and offer a reasonable attempt at explaining that an increase in temperature sees the equilibrium position move to the left hand side.

Question 10(a) is based on a practical technique and requires some higher-level evaluation. This type of question is amongst the most poorly answered every year and this was no exception. Even those candidates that identified the formation of a precipitate as being a problem could not always give an appropriate improvement. It was common to see candidates suggesting that sulfuric acid should be used in place of hydrochloric acid even though this would give a precipitate of lead(II) sulfate.

Question 10(c)(i) was poorly answered. Most candidates struggled to write the equation for the reaction of copper(II) ions with iodide ions. Many candidates who understood that the thiosulfate ions reduce iodine to iodide could not identify the final sulfur-containing product and even those that wrote  $S_4O_6^{2-}$  did not always balance the equation. Where candidates wrote two equations that included the formation and reduction of iodine molecules they could generally use these to show the 1:1 reaction ratio.

Question 10(d)(ii) was poorly answered. Some candidates discussed the inability for electrons to move without giving a reason why. Unclear or incorrect statements such as '*d*-orbitals are empty', '*d*-sub-shell is not partially filled' or 'there is a full *d*-orbital' were common.

Question 10(e) is on electrochemistry. This is one of the most challenging areas for candidates and often has questions with low facility factors. In this case many candidates could not compare standard electrode potentials to come to a conclusion. In part (i) stronger candidates calculated the EMF of the reaction and used its positive value to show that the reaction was feasible. Others compared standard electrode potential values and the standard of these answers was more variable with more vague terms being used, such as 'bigger' or 'smaller', rather than the preferred 'more positive' or 'more negative'.

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### UNIT 4 – ORGANIC CHEMISTRY AND ANALYSIS

#### Overview of the Unit

The examination paper covered the breadth of the specification and included a variety of question types – factual recall, mathematical skills, application of knowledge and certainly depth of knowledge. The questions proved to be accessible, in that candidates were able to attempt every question, but as would be expected, the longer questions were very discriminating with most scoring some marks and only the more able attaining the highest marks.

Some aspects that were problematic last year were better, e.g. optical isomerism and molar mass calculations involving unknown functional groups were far more confidently attempted. However, certain areas of the paper were less well done than expected, e.g. identifying compounds and using their formulae in balanced organic equations.

#### Comments on individual questions/sections

##### Section A

These short questions assessed basic calculations, common organic tests and reagents, practical analysis, mechanisms and general aromatic properties. Most candidates managed to score at least half the marks on offer. Dropped marks in this section tended to be either careless errors or providing incomplete answers. For example, in Q1(c) the moles of the reactant were calculated by almost all, but many did not go on to give the number of moles of gaseous products as needed. In Q2(a) some gave the observation for the iodoform test as a yellow 'solution' rather than precipitate. Q3(b) required candidates to complete a mechanism. Common incorrect answers contained a final molecule with a carbon atom having only three bonds.

##### Section B

This section assesses candidates' depth of knowledge and application of skills across the specification. Three questions [Q5(a), Q6(c)(ii) & Q7(b)(i)] required candidates to prove a given molar mass/ $M_r$  or use a given value to find the identity of an alkyl group. All were very well answered by most. However, similar questions [Q5(b)(iii), Q9(a)(vi) & Q9(b)] where no molar mass was given were clear discriminators. All candidates began them but only the most able worked their way through the problems to arrive at the correct answer.

Familiar calculations were generally very well done but marks were often lost for simple errors in  $M_r$  values for aromatic compounds. This was especially true in Q6(d)(i) where the question required candidates to find the atom economy. Most could use the atom economy equation correctly, but large numbers forgot to add the mass of five hydrogens on the aromatic ring in the reactant and product.

The ability to name organic molecules and give formulae/draw structures for named compounds was again an issue for many. In Q6(c)(i), many did not know the formula for tetrachloromethane and in Q7(b)(iii) very few could name 2,6-dimethylphenol.

Some questions were not read carefully and this led to many needlessly dropped marks. Q5(b)(iv) asked for the addition and condensation polymer repeating units, but many got these confused and/or wrote the same answer for both. Q5(c)(iii) expected candidates to explain the difference in boiling temperatures between two organic compounds, but most lost the mark as they only considered one of them. Q7(c) asked candidates to 'give their reasoning' when selecting organic compounds that gave specific qualitative test results, but many lost all three marks because they identified the compounds but provided no explanation. Finally, Q6(d)(ii) required candidates to suggest methods of monitoring the rate of an organic reaction. Marks were dropped as candidates capably identified appropriate practical methods but neglected to refer to time. Several lost both marks as they misinterpreted the question completely and discussed how changing conditions could speed up the rate of reaction.

Many questions requiring the recall of AS mechanisms [Q6(a)(i) & Q8(a)(i)] were well answered, as were one-mark responses that needed reagents or naming a type of reaction. In addition, Q8(c) about optical isomers was very well answered.

The QER question in this paper was practically based. As expected, only the more able candidates could access the higher band marks and, as ever, it proved to be another discriminating question. Pleasingly, nearly everyone who attempted the question scored at least some marks. The task involved three steps to obtain pure benzoic acid crystals from impure sodium benzoate. Although significant 'scaffolding' information was provided, candidate responses tended to lack detail of any measurements (even though the question requested them). It was common to see incorrect content that contradicted the information provided in the stem of the question. Many candidates talked about 'filtering off' the sodium chloride, even though they were told that it was the benzoic acid that had a low solubility; or suggested filtration of a solution they hadn't prepared, as they were initially provided with a solid sample and not a solution. To obtain marks in the higher band, candidates were expected to refer to filtering an impure solution of sodium benzoate, preparation of benzoic acid and then recrystallisation. The majority of candidates did not include recrystallisation and most scored marks in the range 2-4. Many of those who did mention all three steps did not score a higher band mark as their responses were either vague or included fundamental errors in technique, e.g. reference to 'heating to dryness', 'filtering off a precipitate of sodium chloride' or trying to recrystallise benzoic acid without removing the sodium chloride. Those who did score 5 or 6 marks gave measurements of volume (and in some cases masses, moles and concentration calculations) and all three essential steps in the correct sequence that would allow them to obtain pure benzoic acid crystals at the end.

# CHEMISTRY

## GCE

Summer 2025

### UNIT 5 – EXPERIMENTAL TASK

#### Overview of the Unit

The examination provided candidates with the opportunity to apply their practical skills in carrying out two separate titrations. One was a standardisation task and the other involved the preparation of a 250cm<sup>3</sup> solution using a solid of unknown molecular mass. Candidates were expected to record the results in appropriate tables of their own construction. They analysed their results in order to calculate the unknown molecular mass and subsequently find the value of  $x$  in the formula  $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$ .

The second practical exercise was an organic qualitative analysis, incorporating tests on samples extracted at different stages of a reaction sequence of familiar organic reactions. Candidates recorded the observations and were asked to interpret the outcome of each test with regards to the functional groups that were either present or absent.

#### Comments on individual questions/sections

There was a clear improvement in the quality of the titration tables constructed by the candidates, with most scoring all four marks in this section. The marks awarded for titration accuracy varied considerably between centres rather than within centres. For example, in many centres the majority scored at least five out of the six marks available whilst in others the range of titre values varied considerably from that expected and many subsequently scored lower marks. It was very surprising to see such a variation in titre results for the first titration (between NaOH and HCl), where the candidates should all have got the same value. In a few centres, these titres ranged from 14 cm<sup>3</sup> to 26 cm<sup>3</sup>. It can only be assumed that this results from a lack of practical experience and that perhaps some centres should consider this in planning for the next year.

The molar calculations carried out in parts (i)-(iii) were done well overall, with many being able to accurately use their results to find the molecular mass and the value of  $x$  in  $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$ .

Most candidates realised in part (iv) that hydrogen bonding was needed for the oxalic acid to dissolve in water but far fewer could explain the interaction present for the second mark.

The organic qualitative observations were usually excellent, with most gaining full marks in this section. However, analysis of the results proved problematic for many. In part (v), many candidates lost two marks because they described the test result rather than using it to identify the functional group present/absent from the positive/negative test result. For example, for Step 2 answers such as 'the white precipitate formed was due to the precipitation of silver chloride' gained no credit as they did not state that the observation indicates the presence of a chloroalkane.

Finally, in part (vi) many candidates lost marks as they correctly identified relevant IR peak positions but did not state that they would appear or disappear as the reaction progresses.

# CHEMISTRY

## GCE

Summer 2025

### UNIT 5 – PRACTICAL METHODS AND ANALYSIS TASK

#### Overview of the Unit

Candidates were given the main themes or topic areas for assessment in Unit 5 in January 2025 as is now the established process. This information helped them focus their preparation for the examination and once again this proved to be beneficial. Those covered in the Practical Methods and Analysis Task were as follows:

- qualitative inorganic analysis
- quantitative analysis and calorimetry
- organic compounds containing oxygen

The paper differentiated well with some marks accessible to almost all candidates and others only gained by the most able. This led to a good distribution of marks and a mean mark of 15.6 out of 30.

Good attempts were made at most of the calculations, where many candidates set out their answers sufficiently clearly to be able to see what was being done at each stage, allowing partial credit to be given when final answers were incorrect.

There was no indication that candidates had a problem with the length of the paper, with answer spaces that were left blank tending to indicate a lack of knowledge and understanding rather than a shortage of time.

#### Comments on individual questions/sections

##### Question 1

This question clearly differentiated between those that had revised the inorganic functional group tests and those that had not. It required candidates to name reagents that would distinguish between three sets of aqueous solutions, giving the expected observations and a relevant equation. It was surprising to see that some candidates were unable to score any marks for this question, with a number making no attempt at identifying reagents and observations for one or more sets of compounds.

The common errors seen were as follows:

- Just giving the colours of the inorganic solutions although the question asked for a chemical test
- Poor recall of precipitate colours on addition of sodium hydroxide to solutions of iron(II), iron(III) and chromium(III) salts
- Incorrect formulae and incorrectly balanced equations, e.g. in equations for reactions of metal ions with hydroxide ions and in precipitation of barium sulfate (or barium carbonate)
- Choosing an insoluble sulfate (or carbonate) as the reagent for precipitation of barium sulfate (or barium carbonate)
- Not stating that there would be no observable reaction when sulfate (or carbonate) ions are added to lithium chloride
- Suggesting aqueous silver nitrate as a reagent to distinguish between bromine and iodine.

## Question 2

This question required the candidates to calculate the mass of strontium added to a known volume of water. Method 1, using calorimetry, was not as well answered as method 2, with only a minority scoring both marks. The errors seen included

- not converting the enthalpy change of  $-430 \text{ KJ mol}^{-1}$  into  $-430\,000 \text{ J mol}^{-1}$
- converting temperature change from  $^{\circ}\text{C}$  into K
- calculating the number of moles of water (using the 200 g added to the insulated calorimeter) and using this value in the  $\Delta H$  expression to calculate the 'mass of strontium'
- not using the volume of water at all in their calculation
- using  $q = mc\Delta T$  to incorrectly calculate  $m$  as the mass of strontium.

Method 2, using titration, was well answered with most gaining at least 2 marks. Nearly all candidates were able to calculate the number of moles of hydrochloric acid used in the titration of  $25.0 \text{ cm}^3$  of strontium hydroxide solution and were then able to scale this up to the  $200 \text{ cm}^3$  total volume. A few candidates lost marks because they:

- didn't use the 2:1 mole ratio of HCl to  $\text{Sr}(\text{OH})_2$
- used the  $M_r$  of  $\text{Sr}(\text{OH})_2$  rather than the  $A_r$  of strontium to calculate the mass of strontium added.

Asked to identify which of the two methods gave the most accurate value for mass, the majority of candidates correctly chose the titration, stating reasons such as:

- the thermochemical method involves heat losses
- the burette has a smaller uncertainty ( $\pm 0.05 \text{ cm}^3$ ) than the thermometer ( $\pm 0.1^{\circ}\text{C}$ ).

Any reference to repeats or concordance alone, without any reference to accuracy, did not gain the mark.

A surprising number of candidates did not correctly calculate the maximum percentage error for the temperature change value. The most common incorrect answer was 3.3%, with candidates not doubling the uncertainty of  $\pm 0.1^{\circ}\text{C}$  to account for initial and final readings. The calculated value also had to be given to a minimum of 1dp to be awarded the mark.

## Question 3

- (a) Almost all candidates gained the available mark.
- (b) In part (i) most candidates scored at least 2 marks for this reacting mass calculation. Some lost a mark after calculating an incorrect  $M_r$  for the acid and others failed to convert the mass of ethanoic anhydride into a volume. Part (ii) was poorly answered by weaker candidates who often attempted to calculate the percentage yield without finding any  $M_r$  values or the number of moles of reactant and simply divided the mass of reactant by the mass of product and multiplied by 100.
- (c) Many candidates were able to link the purple colour with aqueous  $\text{FeCl}_3$  and the vinegar-like smell to the presence of a phenolic group and ethanoic. They had to refer to *hydrolysis* of the aspirin to gain both marks.
- (d) Well answered with most candidates correctly referring to ethanoyl chloride being more expensive or reaction with ethanoyl chloride releasing toxic hydrogen chloride gas.

- (e) Parts (i) and (ii) were generally well answered with many candidates gaining both marks. There were several acceptable answers in part (ii). In part (iii), a surprisingly small number gave the correct peak ratio of 3:4. The majority forgot about the hydrogen atoms in the aromatic ring.

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